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# A Focus on Mathematical Literacy to Increase Student Understanding and Performance

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A Focus on Mathematical Literacy to Increase  
Student Understanding and Performance

Rachel Alvarez

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A thesis project submitted to the Department of Education and Human Development of the State University of New York College at Brockport in partial fulfillment of the requirements for the degree of Master of Science in Education.

**Abstract**

This curriculum project was designed to help promote mathematical literacy within applications of quadratic functions. The curriculum bridges literacy strategies with mathematical applications so that the two build upon each other in a lesson rather than being two separate entities. These materials are aligned with the Algebra I New York State Common Core Learning Standards.

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### **Introduction**

The Common Core State Standards (CCSS) were created to set consistent, high standards across the country that would prepare students for their futures, whether that be going to college or pursuing a career (NGA Center, 2010). Colleges reported that four out of every 10 students had to take remedial courses, extending the timeline and cost of college (U.S. Department of Education, 2010). Standards and expectations varied by state, and prior to the implementation of the CCSS, it was possible that a student be labeled proficient according to one state's standards and not proficient in another. The use of the National Assessment of Educational Progress (NAEP) helped call attention to this, as the range of scores varied greatly between states, and there often was no link between NAEP scores and the proficiency levels that states reported (U.S. Department of Education, 2010). The CCSS include both content and process standards, as did many states' standards previously, however, now those standards were made consistent for all the states that adopted them. Within the CCSS for Mathematics, four of the process standards in particular help push students towards higher levels of Bloom's taxonomy (Roepke & Gallagher, 2015), focusing less on rote memorization and procedures and more on application and reasoning (Porter, McMaken, Hwang, & Yang, 2011, p. 114). The ability to apply learned material to new situations and the ability to reason are skills that were identified as indicating college and career readiness (NGA Center, 2010). The four CCSS process standards are:

Make sense of problems and persevere in solving them; Reason abstractly and quantitatively; Construct viable arguments and critique the reasoning of others; and Model with mathematics (NYSED).

To more fully master the CCSS, especially the process standards, students need to learn how to better communicate mathematically, or become more mathematically literate. Traditionally, literacy and mathematics were thought of as being on opposite ends of the spectrum (Kester Phillips, Bardsley, Bach, & Gibbs-Brown, 2009). Literacy educators often leave out examples of implementing their strategies in mathematics, and mathematics educators scoff at the idea of adding reading strategies in to their already oversaturated mathematics curriculum. As stated by Robin, Chilla, and Gardner (2015), “If you don’t know content, you will have a difficult time understanding the texts, and if you don’t understand the texts, you are unlikely to learn content” (p. 5). While the previous statement seems obvious, there has historically been a lack of communication and understanding between the fields of mathematics and literacy (Draper & Siebert, 2004).

### **Problem Statement**

There are plenty of news stories about how American students are falling further behind in their schooling, especially in mathematics. For example, in 2015 the Program for International Student Assessment (PISA) test was given to fifteen year olds across the world, and the United States ranked 31<sup>st</sup> out of the thirty-five industrialized countries that participated (Barshay, 2016).

According to the National Academies of Sciences, Engineering, and Medicine, “American employers are demanding workers with greater proficiency in literacy and numeracy and strong interpersonal, technical, and problem-solving skills” (2017).

### **Rationale**

The purpose of this curriculum study is to focus on Algebra I and literacy simultaneously to increase student understanding and performance. The unit is aligned to CCSS for Algebra I and utilizes strategies to develop students’ mathematical literacy. The unit will begin with an overview of key vocabulary pertaining to quadratic functions, most of which they should be familiar with, but will now aim for a deeper understanding. The unit will then develop in to two different trajectories, geometric applications and projectile motion. Instructional strategies to promote mathematical literacy will be implemented throughout to help students better understand how to approach and solve word problems. Along with the strategies embedded in to the curriculum, it is imperative that students are given every opportunity possible to communicate mathematically with others. It is also beneficial to allow students some ‘struggle time’, allowing students to think through a problem and find success rather than waiting for the teacher or someone else to tell them how to work the problem.

## **Literature Review**

### **Mathematical Literacy**

Before teachers can be expected to teach mathematical literacy, they must first understand it themselves. As said by Draper & Siebert, “literacy is essential to the process of developing understanding” (2004). There are many different, yet related, definitions in the literature, most of which touch upon the importance of understanding and doing mathematics. Robin, Chilla, and Gardner (2015), discussed the need to distinguish disciplinary literacy from content area literacy. “Content-area literacy refers to using the language arts teacher’s approaches to reading, writing, listening, speaking, and thinking in the content areas” (p. 1). Content area literacy strategies do have value and can be utilized across disciplines, however, they are not enough to gain the conceptual understanding necessary to master the aforementioned CCSS process standards. Disciplinary literacy is defined as “the typical ways of thinking, doing, speaking, writing, and representing within the context of a given discipline” (Robin, Chilla, & Gardner, 2015, p. 1). In essence, disciplinary literacy in mathematics is learning to think, speak and work like a mathematician. The term mathematical literacy will be used from this point forward to represent disciplinary literacy within mathematics. In elementary school students learn how to read and write, but at the secondary level reading and writing shift to being tools for learning in each specialized content area (Draper & Siebert, 2004). In high school mathematics, language arts teachers take a secondhand role in mathematical literacy because the mathematics



teacher is the expert in the nuances of thinking, speaking, and working like a mathematician.

The recent focus on disciplinary literacy is due, in part, to the implementation of the CCSS and the need for students to deepen their understanding of the mathematics they are learning. One of the buzz phrases in education today is “student centered”, which transforms the traditional mathematics classroom of a teacher “giving” mathematical knowledge to students and expecting them to practice and memorize it, to a student centered classroom that favors students discovering new ideas for themselves (Draper, 2002, p. 521). This goes hand-in-hand with disciplinary literacy and the goal of “knowledge production of content instead of knowledge banking” (Robin, Chilla, & Gardner, 2015, p. 7). For example, it is no longer enough for a student to memorize that the equation of a line is  $y = mx + b$ . Now more than ever it is expected that the student understands how the slope and y-intercept is derived, know that a linear function has a constant rate of change, be able to recognize and transform the line between multiple representations of graphs, equations, and tables, and to be able to apply their knowledge of a linear function in the context of a real life situation. The teacher must set up opportunities for the students to “question, probe, and ponder” the mathematics (Draper, 2002, p. 523) and typically this is a time consuming transition that is as uncomfortable for the students as it is for the teacher. In one study, a teacher found that if the students didn’t easily find meaning when reading a new problem they would give up, and students cannot learn if they

are not trying to learn (Meaney & Flett, 2006). Students often surprise themselves with how much they know when they are asked probing questions and pushed to communicate their thinking with others. It is with this problem solving approach to mathematics and the right teacher guidance that students can become better at communicating their ideas and reasoning through problem solving to find viable solutions. This approach encourages students to take ownership of their learning, thus making it more meaningful and promoting a higher level of understanding (Draper & Siebert, 2004).

**Implementation Strategies:**

One of the major difficulties students have with mathematics is vocabulary. Not only are there new words that students must learn and understand, but some words that they are already familiar with have a different meaning within mathematics. For example, *parabola* is a word that is new students in mathematics and students learn to define it as the u-shaped graph formed by a quadratic equation. On the other hand, when a student is introduced to the word *mean* in math class they may assume that they already know the definition as the opposite of nice, however it is actually defined as the average when used in mathematics. To combat the confusion that vocabulary in mathematics can present, Roepke and Gallagher (2015) suggest that words falling under the category of “technical jargon” and words with double meanings need to be explicitly taught (p. 49). Discuss these words with the students, clearly point out the differences between the plain English definition

and the mathematical definition, allow for discussion, and provide examples (Hersh, 1997). One way to help students understand new vocabulary and key concepts is to utilize the Frayer model (Roepke & Gallagher, 2015). Robin, Chilla, and Gardner (2015) discuss a modified Frayer model for mathematics which includes the vocabulary word in the middle, the usual four boxes for definition, examples, non-examples, and characteristics, but also adds a fifth category for including a visual representation. Another vocabulary strategy is for students to create their own student-defined glossary; by allowing students to put the definitions in their own words they are showing their understanding of the word or concept, and will take more ownership of the material because it is something they personally came up with (Meaney & Flett, 2006).

The nature of mathematical texts is inherently different from that of other disciplines with more concepts packed in each sentence, the use of both numeric and non-numeric symbols, and diagrams (Robin, Chilla, & Gardner, 2015). Students cannot simply read and get the gist, as mathematical texts tend to be much more precise than typical reading (Kester Phillips, Bardsley, Bach, & Gibbs-Brown, 2009). Even the definition of what a mathematical text has shifted from just being a textbook to “include anything that provides readers, writers, listeners, speakers, and thinkers with the potential to create meaning through language” (Draper, 2002, p. 523) This essentially means that every piece of mathematics students encounter is considered text, and it is the teacher’s job to help them comprehend the text. The drive towards a student-centered classroom is the focus for many today, often making teachers nervous

to “lecture” or stand at the board teaching students. According to Kester Phillips, Bardsley, Bach, & Gibbs-Brown (2009), students need to be explicitly taught how to read mathematical text, and doing so will help improve the student’s communication within mathematics. Just as it is not reasonable to expect a student to sit with a group of his/her peers and discover the Spanish language on their own, the same can be said for the language of mathematics. It is impractical to expect students to have the skills needed to read a mathematical text without the help of someone more knowledgeable in the content (Draper, 2002). A think aloud is a modeling strategy in which the teacher shares out loud the thoughts, questions, and visualizations he or she is utilizing to understand a text (Robin, Chilla, & Gardner, 2015). This strategy takes time and patience, but consistent reinforcement can lead students to change their own reading habits in math and gain a deeper understanding when reading mathematical texts (Meaney & Flett, 2006).

A reading strategy that can be adapted for mathematics is a KWL. This strategy is particularly useful while solving complex word problems as it asks students what they know, what they want to know, and what they learned from the reading or problem (Draper, 2002). One benefit of a KWL is to help identify non-content vocabulary that students are struggling with (Kester Phillips, Bardsley, Bach, & Gibbs-Brown, 2009). Roepke and Gallagher (2015) discuss the use of an anticipation guide, or guided questions, to activate students’ background knowledge when reading a word problem, and this strategy can combine with the use of a KWL. A KWL with guiding questions can focus

student thinking and create discussion in the classroom. Implementing this strategy will take a good deal of teacher persistence since students may initially be uncomfortable admitting things they don't know, or may not yet feel confident in what they do know (Draper, 2002).

### **Unit Plan**

The proposed unit on applications of quadratic functions will be taught after the conclusion of the quadratic functions unit. While both units deal with quadratic functions, they were separated due to the nature of the learning. The first unit on quadratic functions focuses on acquiring information about quadratics and skill-based processes, whereas the second unit on quadratic functions utilizes higher-level thinking since it is applying what was learned about quadratics to real-world situations. Modeling is a major focus on the Common Core State Standards and this unit addresses that. Each lesson is planned for a forty-five to fifty minute class period. Word problems used in these lessons were modified from previous Algebra I Regents exam questions (NYSED, 2017).

Also included with the materials are the weekly warm up and the habits of work student self-reflection. These are daily rituals and routines that students have grown accustomed to. The warm up helps students come in to class, get focused, and begin thinking mathematically. Students may use notes for the warm up but otherwise they are supposed to complete it independently. At the end of the week the warm up is graded and students are able to make corrections or come during lunch for clarification if needed. The habits of work self-reflection is a way for students to self-assess on a daily basis, reflecting on how they performed as a student that day.

**Calendar**

<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>
Lesson 1: Characteristics of a Quadratic Function	Lesson 2: KWL's and Geometric Applications	Lesson 3: Geometric Applications of Quadratic Functions	Lesson 4: Projectile Motion	Applications of Quadratic Functions Assessment
☉ I can correctly identify and discuss the different characteristic of the graph of a quadratic functions.	☉ I can use a KWL chart to help me solve a word problem.	☉ I can create a quadratic equation to solve a real- world problem.	☉ I can interpret important points on a quadratic graph within a given context.	☉ I can show my knowledge of quadratic applications by solving real- world problems.

**Warm Up**

Name \_\_\_\_\_

Week of: \_\_\_\_\_

**Learning Targets:**

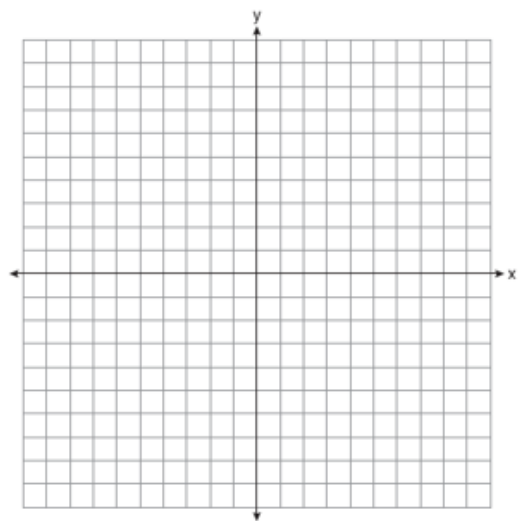
- ✓ I can factor a quadratic expression in order to reveal its zeros.
- ✓ I can graph linear, exponential, and quadratic functions that are expressed symbolically.

**Day 1**

1. Solve  $m^2 - 5m = -6$  for  $m$  by factoring.
2. Solve the equation for  $x$   
 $(7x - 1)(2x + 5) = 0$

**Day 2**

1. The zeros of the function  $f(x) = 3x^2 - 3x - 6$  are
2. On the set of axes below, graph the equation  $y = x^2 + 2x - 8$ . Using the graph, determine and state the roots of the equation  $x^2 + 2x - 8 = 0$ .

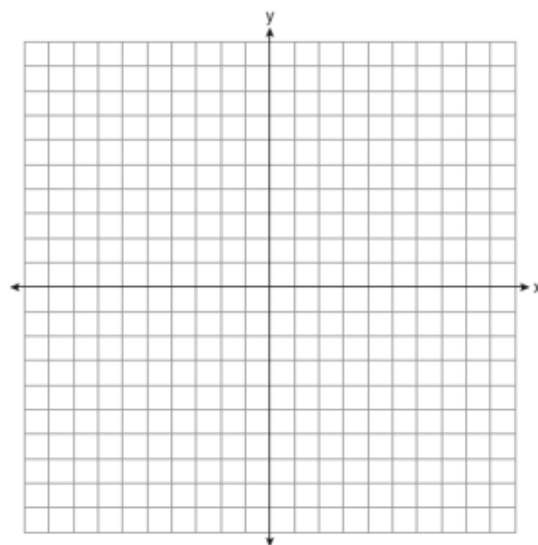




**Day 3**

---

1. What is the difference between zeros and roots?
2. On the set of axes below, graph  $y = x^2 - 6x - 19$ . Circle the roots.

**Day 4**

---

1. Keith determines the zeros of the function  $f(x)$  to be  $-6$  and  $5$ . What could be Keith's function? *Hint: Work backwards.*
2. What is the axis of symmetry and vertex of yesterday's warm up graph?

**Student Daily Self-Reflection**

Name \_\_\_\_\_ Prd \_\_\_\_\_ Dates \_\_\_\_\_

**HOW to be a LEADER**

HOW – Habits of Work

LEAD – Listen, Engage, Attend, Dedication

Place a checkmark for every 'yes' today.

	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Listen: did you respect yourself?						
Listen: did you respect others?						
Engage: was your phone away?						
Engage: were you actively participating?						
Attend: were you on time to class?						
Attend: were you paying attention the whole time?						
Dedication: did you do your best?						
Dedication: did you refuse to give up?						
Total						

**Lesson 1**

<b>Lesson Title</b>	Characteristics of a Quadratic Function
<b>CCSS Mathematics</b>	F-IF.C.7a: Graph linear and quadratic functions and show intercepts, maxima, and minima.
<b>CCSS for Mathematical Practice</b>	<input type="checkbox"/> 1. Make sense of problems and persevere in solving them. <input type="checkbox"/> 2. Reason abstractly and quantitatively. <input type="checkbox"/> 3. Construct viable arguments and critique the reasoning of others. <input type="checkbox"/> 4. Model with mathematics. <input type="checkbox"/> 5. Use appropriate tools strategically. <input checked="" type="checkbox"/> 6. Attend to precision. <input type="checkbox"/> 7. Look for and make use of structure. <input type="checkbox"/> 8. Look for and express regularity in repeated reasoning.
<b>Learning Target</b>	Students will be able to... ...correctly identify and discuss the different characteristics of the graph of a quadratic function.
<b>Level of Rigor</b>	<input checked="" type="checkbox"/> Conceptual understanding <input type="checkbox"/> Procedural skill & fluency <input type="checkbox"/> Application
<b>Opening</b>	Complete an example Frayer model on the board as a class. Let the students vote if they would like to use football or pizza as the example vocabulary word.
<b>Lesson/ Activities</b>	Students will complete six Frayer models with partners or independently. Mathematical discussion is encouraged throughout this activity, and students will be directed to ask questions of each other and to utilize their notes instead of coming to me for help.
<b>Formative Assessment</b>	Circulate the room to check for student understanding and to address any misconceptions that may arise. Ensure that students understand that the maximum or minimum is related to the vertex.
<b>Materials</b>	<ul style="list-style-type: none"> <li>- Vocabulary list</li> <li>- Frayer model templates</li> </ul>

Name\_\_\_\_\_ Class\_\_\_\_\_ Date\_\_\_\_\_

## Quadratic Functions Vocabulary

Directions: Create a unique Frayer model for each of the following terms. These words are review from our Introduction to Quadratics unit, so please utilize past notes to help you. Your Frayer model must include the word, definition, examples, non-examples, characteristics, and a visual representation.

Parabola

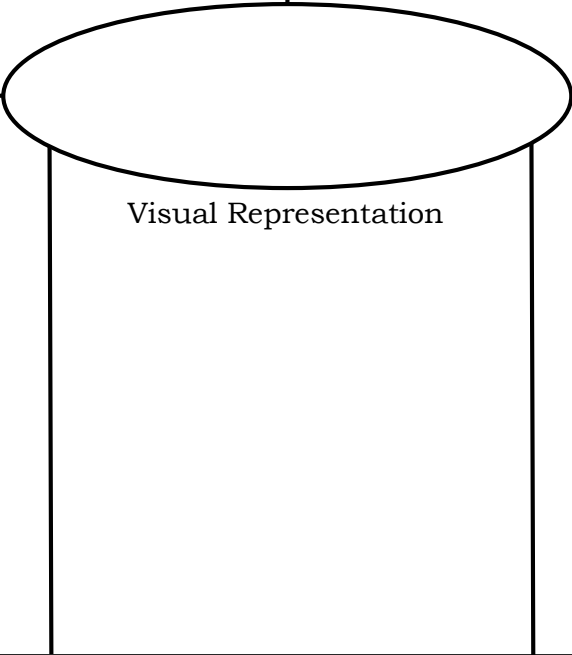
Vertex

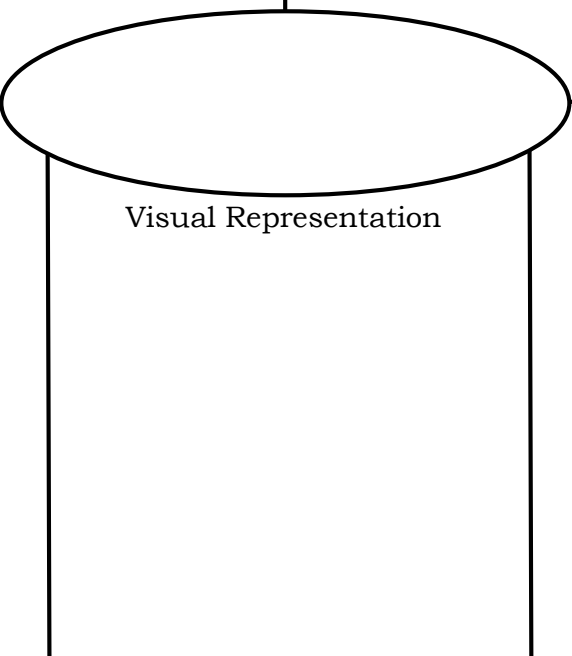
Axis of Symmetry

Minimum

Maximum

Zeros/Roots/Solution/X-intercepts  
(can be on the same Frayer model)

Definition		Facts/Characteristics
Examples	 <p>Visual Representation</p>	Non-examples

Definition		Facts/Characteristics
Examples	 <p>Visual Representation</p>	Non-examples

**Lesson 2**

<b>Lesson Title</b>	KWL's and Geometric Applications
<b>CCSS Mathematics</b>	A-CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.  F-IF.C.7a: Graph linear and quadratic functions and show intercepts, maxima, and minima.
<b>CCSS for Mathematical Practice</b>	<input checked="" type="checkbox"/> 1. Make sense of problems and persevere in solving them. <input type="checkbox"/> 2. Reason abstractly and quantitatively. <input type="checkbox"/> 3. Construct viable arguments and critique the reasoning of others. <input type="checkbox"/> 4. Model with mathematics. <input type="checkbox"/> 5. Use appropriate tools strategically. <input type="checkbox"/> 6. Attend to precision. <input type="checkbox"/> 7. Look for and make use of structure. <input type="checkbox"/> 8. Look for and express regularity in repeated reasoning.
<b>Learning Target</b>	Students will be able to... ...use a KWL chart to help them with the process of solving a word problem. ...create a quadratic equation that will lead them to a solution.
<b>Level of Rigor</b>	<input type="checkbox"/> Conceptual understanding <input checked="" type="checkbox"/> Procedural skill & fluency <input type="checkbox"/> Application
<b>Opening</b>	<p>Start with a KWL chart on the board, and begin a discussion with the students about Christmas gifts they may get. (This can be changed to any topic the students would feel familiar with i.e. a television show, movie, what's for lunch, etc.) Take notes in the appropriate column as students reply.</p> <ul style="list-style-type: none"> <li>- What gifts did you ask for? (<b>K</b>now)</li> <li>- Did you get what you asked for in the past? (<b>K</b>now)</li> <li>- Do your parents/guardians have a lot of people to get gifts for? (<b>K</b>now or <b>W</b>ant to know)</li> <li>- Has anything happened recently that may stop them from buying gifts? (<b>K</b>now or <b>W</b>ant to know)</li> <li>- Ask the students what questions they have about receiving Christmas gifts. (<b>W</b>ant to know)</li> </ul> <p>Stop once the <b>K</b>now and <b>W</b>ant to know columns are filled out and ask students why there is not any information in the <b>L</b>earned column. If needed ask a guiding question such as, Can we know for sure what we are going to receive before we actually receive it? Point out that we cannot discuss what we have <b>L</b>earned until the actual</p>

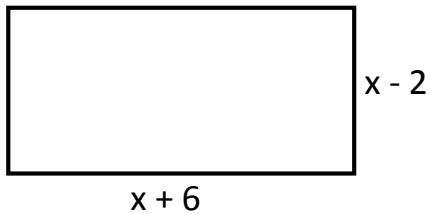
	day comes, or in math we cannot talk about the solution in detail until we have done the work to solve the problem.
<b>Lesson/ Activities</b>	<p>Provide students with a KWL chart of their own, as well as the Geometric Applications worksheet. Ask them to read #1 and fill in their KWL accordingly. After 2-3 minutes, call on students to share what they wrote down. Likely their notes will be minimal at this point as this is a new process.</p> <p>For the <b>K</b>now column, make sure that students have noted the expressions representing the length and the width, the numerical value of the area, and that they have recalled the formula for area of a rectangle.</p> <p>For the <b>W</b>ant to know column, ask students what the problem is asking them to find, if they have not included that already. Also explain to students that if there are any words they aren't sure of that those should also be included in this column so that we may clarify them.</p> <p>Ask students to substitute what they know in to their area formula and solve for <math>x</math>. (Students will be instructed to solve using the zero function of their graphing calculator. They just completed a unit on solving by factoring or using the quadratic formula, and have been introduced to solving a quadratic with their calculator. The focus of this unit is on the problem solving process, not on how to solve a quadratic algebraically.) Allow students to solve without any additional guidance from the teacher. The exit ticket questions will lead students to think through their solution and what can be put in to the <b>L</b>earned column of their KWL.</p>
<b>Formative Assessment</b>	Exit Ticket (This will help make sure that students found both the length and the width and did not just stop when they found a value for $x$ .)
<b>Materials</b>	<ul style="list-style-type: none"> <li>- KWL's and Geometric Applications</li> <li>- Exit ticket</li> </ul>

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## KWL's and Geometric Applications

Directions: Read the following word problem and fill out your KWL to help you find a solution.

Find the length and the width of the following rectangle if the area is 105 square inches.





Topic/Problem #-----

I Know	I Want to know	I Learned

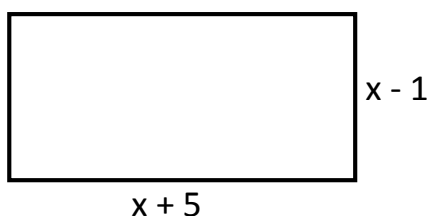
Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## Exit Ticket

Below is a sample of work from a problem similar to the one you did in class today. This student did not earn full credit for their work and isn't sure why, please help the student find their error.

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>

Find the length and the width of the following rectangle if the area is 160 square inches.



The student did not earn full credit because \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Lesson 3**

<b>Lesson Title</b>	Geometric Applications of Quadratic Functions
<b>CCSS Mathematics</b>	A-CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.  F-IF.C.7a: Graph linear and quadratic functions and show intercepts, maxima, and minima.
<b>CCSS for Mathematical Practice</b>	<input checked="" type="checkbox"/> 1. Make sense of problems and persevere in solving them. <input checked="" type="checkbox"/> 2. Reason abstractly and quantitatively. <input type="checkbox"/> 3. Construct viable arguments and critique the reasoning of others. <input checked="" type="checkbox"/> 4. Model with mathematics. <input type="checkbox"/> 5. Use appropriate tools strategically. <input type="checkbox"/> 6. Attend to precision. <input type="checkbox"/> 7. Look for and make use of structure. <input type="checkbox"/> 8. Look for and express regularity in repeated reasoning.
<b>Learning Target</b>	Students will be able to... ...use a KWL chart to help them with the process of solving a word problem. ...create a quadratic equation that will lead them to a solution.
<b>Level of Rigor</b>	<input type="checkbox"/> Conceptual understanding <input checked="" type="checkbox"/> Procedural skill & fluency <input checked="" type="checkbox"/> Application
<b>Opening</b>	The opening will vary slightly depending on the students' level of understanding with the exit ticket the day before. Most likely, many students will have not found the error, or if they did find it they may have to go back and fix/finish their solution from yesterday. Likely, misconceptions may need to be addressed if students provided both the negative and positive answers to yesterday's problem.
<b>Lesson/ Activities</b>	Do a think aloud and model how to fill out the KWL chart for the first problem on the Geometric Applications of Quadratic Functions worksheet. Students should be filling out their KWL as the teacher completes one on the board. Pause frequently to see if students have any questions. For example, in problem 1 show students how to draw a visual representation of the dance floor as it is now, and then the overlay of the expanded version. Ask for student input on how to represent the new length and width of the expanded dance floor. (Remind students of the commutative property, especially if different but equivalent answers are given i.e. $x + 5$ is equivalent to $5 + x$ ) Once you have modeled how to fill out the KWL and set up an equation, have students try to solve the equation using their

	<p>calculator. Monitor the room for students that may be having difficulty with the calculator.</p> <p>Once students solve the problem, come back as a whole group and discuss why it is okay to stop after finding <math>x</math> in this problem, even though that wasn't okay in yesterday's example. Also, point out again why a negative answer would not be reasonable in this situation. At this point, use professional judgement on the level of assistance students will need to continue on. Ideally, they will be able to work in partners while the teacher monitors the room and checks for understanding.</p>
<b>Formative Assessment</b>	Checks for understanding throughout lesson and during work time.
<b>Materials</b>	<ul style="list-style-type: none"><li>- KWL charts</li><li>- Geometric Applications of Quadratic Functions worksheet</li></ul>

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

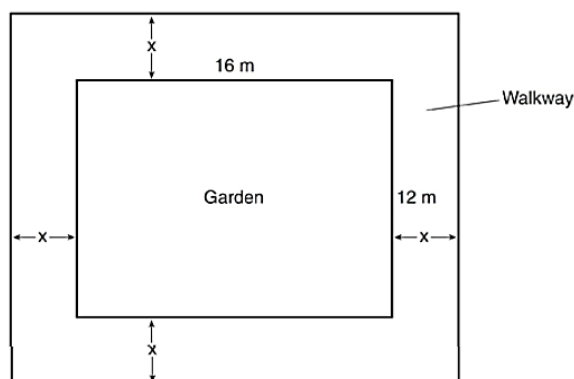
## Geometric Applications of Quadratic Functions

Directions: Read each of the following word problems and fill out your KWL to help you find a solution.

1. Faith is having a rectangular dance floor at her Sweet 16 birthday party. The dance floor currently measures 8 feet by 5 feet. She wants to increase the length and width by the same amount so that the total area of the dance floor is 108 square feet. How many feet will Faith need to add to each side?

2. A rectangular garden measuring 12 meters by 16 meters is to have a walkway installed around it with a width of  $x$  meters, as shown in the diagram below. Together, the walkway and the garden have an area of 396 square meters.

Write an equation that can be used to find  $x$ , the width of the walkway.



Determine and state the width of the walkway.

3. A school is building a rectangular lacrosse field that has an area of 6000 square yards. The lacrosse field must be 40 yards longer than its width. Find the dimensions of the field, in yards.
4. Alexis has 48 meters of fencing to use around the perimeter of her rectangular garden. The length of one side of the garden is represented by  $x$ , and the total area of the garden is 108 square meters. What are the dimensions of the garden?

Topic/Problem #: \_\_\_\_\_

I <u><b>K</b></u> now	I <u><b>W</b></u> ant to know	I <u><b>L</b></u> earned

Topic/Problem #: \_\_\_\_\_

I <u><b>K</b></u> now	I <u><b>W</b></u> ant to know	I <u><b>L</b></u> earned

**Lesson 4**

<b>Lesson Title</b>	Projectile Motion
<b>CCSS Mathematics</b>	<p>F-IF.B.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.</p> <p>F-IF.C.7a: Graph linear and quadratic functions and show intercepts, maxima, and minima.</p>
<b>CCSS for Mathematical Practice</b>	<ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> 1. Make sense of problems and persevere in solving them.</li> <li><input type="checkbox"/> 2. Reason abstractly and quantitatively.</li> <li><input type="checkbox"/> 3. Construct viable arguments and critique the reasoning of others.</li> <li><input checked="" type="checkbox"/> 4. Model with mathematics.</li> <li><input type="checkbox"/> 5. Use appropriate tools strategically.</li> <li><input type="checkbox"/> 6. Attend to precision.</li> <li><input type="checkbox"/> 7. Look for and make use of structure.</li> <li><input type="checkbox"/> 8. Look for and express regularity in repeated reasoning.</li> </ul>
<b>Learning Target</b>	<p>Students will be able to...</p> <p>...use a KWL chart to help them with the process of solving a word problem.</p> <p>...decide whether they need to find the zeros or vertex of a quadratic function, and find them in context.</p>
<b>Level of Rigor</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Conceptual understanding</li> <li><input checked="" type="checkbox"/> Procedural skill &amp; fluency</li> <li><input checked="" type="checkbox"/> Application</li> </ul>
<b>Opening</b>	<p>Once students have entered class, the teacher will climb up on to a table or chair and throw something up in the air. Once the item has dropped to the ground ask the students to make observations about what they saw. Ask the following guiding questions if necessary:</p> <ul style="list-style-type: none"> <li>- Did the height of the object increase or decrease? Or both?</li> <li>- What was the approximate height of the object at the start of the demo?</li> <li>- What was the height of the object at the end of the demo?</li> <li>- What kind of graph would be best to compare the time and height of the object?</li> </ul>



<b>Lesson/ Activities</b>	<p>Students work collaboratively with classmates on the Projectile Motion problems using their KWL to activate prior knowledge, reveal pertinent information given in the problem, and to help them decide whether the problem is asking them to find the vertex, the zeros, or both. Monitor students' progress and if necessary, go over the first problem as a whole group. Students are encouraged to help one another before asking the teacher, so that the students are practicing their mathematical communication.</p> <p>Monitor student progress throughout the work time. Be prepared to help students find an appropriate scale for their graph for problem #4.</p>
<b>Formative Assessment</b>	Exit Ticket - reflection
<b>Materials</b>	<ul style="list-style-type: none"><li>- Chair or table, object to throw</li><li>- KWL charts</li><li>- Projectile Motion worksheet</li><li>- Exit ticket</li></ul>

Name\_\_\_\_\_ Class\_\_\_\_\_ Date\_\_\_\_\_

## Projectile Motion

Directions: Read each of the following word problems and fill out your KWL to help you find a solution.

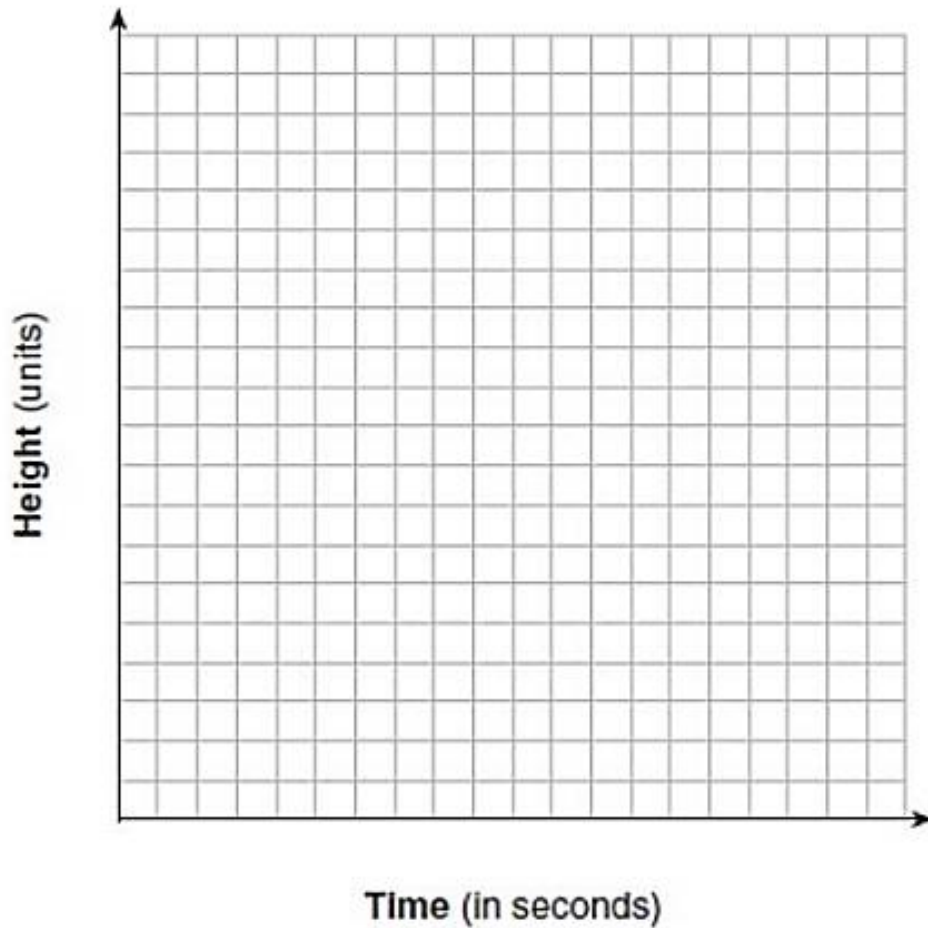
1. Quadir tossed a penny into the air while standing on a 20 foot high bridge. The path of the penny's height can be modeled by the equation  $h(t) = -16t^2 + 40t + 20$ . Find the maximum height of the penny. Justify your answer.

2. Chynia and Dihyona threw their math books out of a window that is 20 feet from the ground. Using the equations of the books' paths below, whose book will reach the ground first? By how many seconds?

Chynia:  $h(t) = -16t^2 + 20$

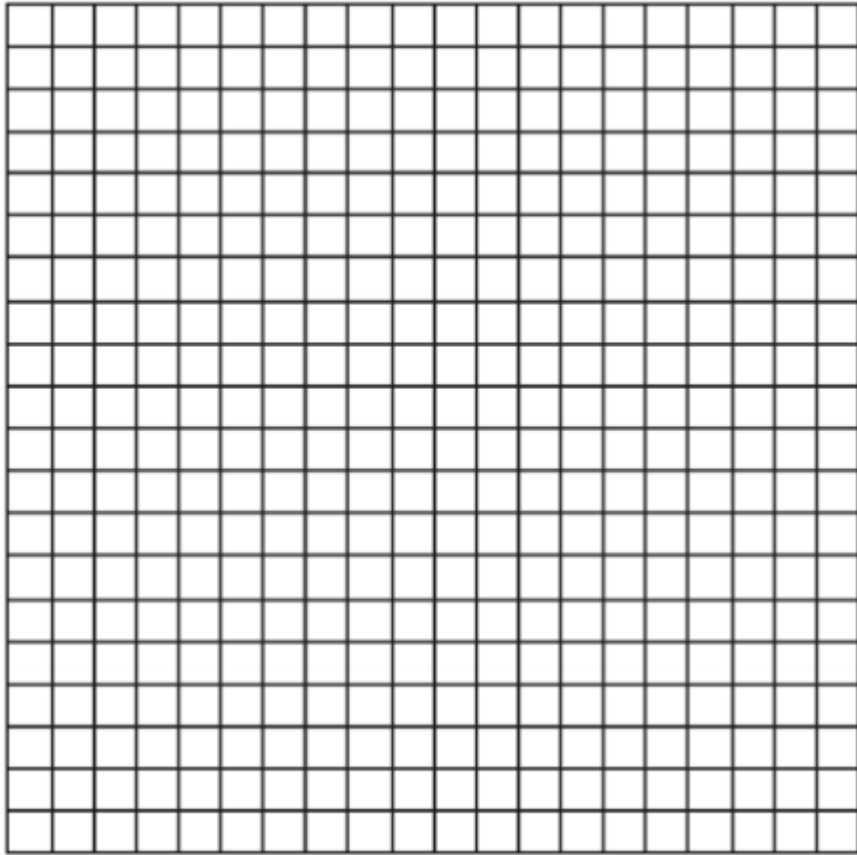
Dihyona:  $-16t^2 + 8t + 20$

3. Alex launched a ball into the air. The height of the ball can be represented by the equation  $h = -9.8t^2 + 49t + 5$ , where  $h$  is the height, in units, and  $t$  is the time, in seconds, after the ball was launched. Graph the equation from  $t = 0$  to  $t = 5$  seconds.



State the coordinates of the vertex and explain its meaning in the context of the problem.

4. The path of a rocket fired during the a fireworks display is given by the equation  $s(t) = 64t - 16t^2$ , where  $t$  is the time, in seconds, and  $s$  is the height, in feet. What is the maximum height, in feet, the rocket will reach? How many seconds will it take for the rocket to hit the ground?



Topic/Problem #:\_\_\_\_\_

I <u>Know</u>	I <u>Want</u> to know	I <u>Learn</u> ed

Topic/Problem #:\_\_\_\_\_

I <u>Know</u>	I <u>Want</u> to know	I <u>Learn</u> ed

**Assessment**

The following assessment is suggested as a task to be completed in class, although it could be a take home assignment if necessary. It can either be given individually, with a main goal of checking students' mastery of quadratic applications, or it can be given as a partner assignment to promote further mathematical discussion. A third option is a combination of the two, and while it is more time consuming it would allow for both individual assessment and communication. The third option is to have students complete the assessment on their own first, make copies of the completed assessments, and then have them work with a partner or triad the next day to compare answers and come up with a final paper with solutions they all agreed upon.

\*Provide students with the KWL charts for this assessment. The next time that word problems arise in class, show students how they can create their own KWL, as they will not be given the aid when taking the Algebra I Regents exam.

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## Applications of Quadratic Functions Assessment

Directions: Answer each question with the correct term.

1. What is a vertex called when it is the lowest point of a parabola?

\_\_\_\_\_

2. What is a vertex called when it is the highest point of a parabola?

\_\_\_\_\_

3. What are three different names for the point(s) where a parabola intersects the x-axis?

\_\_\_\_\_

\_\_\_\_\_

4. What is the U-shaped curve called that is created by a quadratic function?

\_\_\_\_\_

5. What is the name of the turning point of a parabola?

\_\_\_\_\_

6. What is the vertical line that cuts a parabola into two equal parts?

\_\_\_\_\_

7. A circus acrobat is shot out of a cannon with an initial upward speed of 50 ft/sec. The equation for the acrobat's pathway can be modeled by  $h = -16t^2 + 50t + 4$ .

a. Find the maximum height of the acrobat.

---

b. How long will it take to reach the ground?

---

8. The length of a rectangle is five feet less than its width. If the area of the rectangle is 84 square feet, find its dimensions.

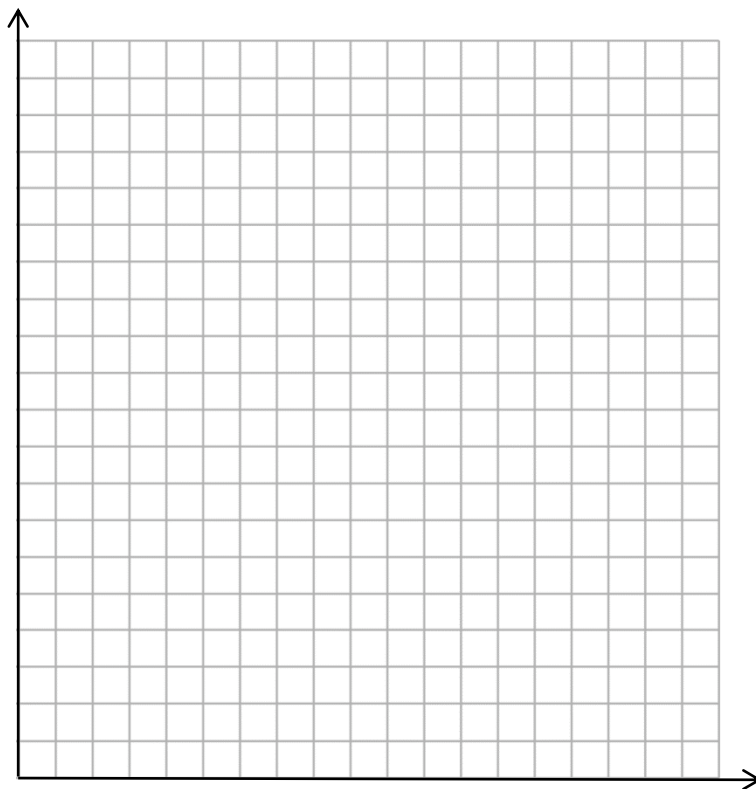
Length \_\_\_\_\_

Width \_\_\_\_\_



9. As part of his science fair project, Jordan launched a model rocket from a platform in the middle of a field. The function  $h(t) = -16t^2 + 72t + 7$  represents the height, in feet, of the rocket, and  $t$  represents the time, in seconds, since the rocket was launched.

- a. Graph and label  $h(t)$  on the grid below from the time the rocket is launched ( $t = 0$ ) until it hits the ground.



- b. Determine the maximum height of the rocket *and* the time it takes the rocket to reach that height. **Label the point** on your graph that represents where this occurs.

max height \_\_\_\_\_

time \_\_\_\_\_

- c. State how long it takes the rocket to hit the ground *to the nearest tenth of a second*. **Label the point** on your graph that represents where this occurs.

\_\_\_\_\_

Topic/Problem #: \_\_\_\_\_

I <u>Know</u>	I <u>Want</u> to know	I <u>Learn</u> ed

Topic/Problem #: \_\_\_\_\_

I <u>Know</u>	I <u>Want</u> to know	I <u>Learn</u> ed

### **Validation of Curriculum**

This curriculum was reviewed and validated by an instructional coach from an upstate New York school. She has sixteen years of experience in the classroom and more than 4 years of experience as an instructional coach. The depth and breadth of knowledge that this teacher has will validate this curriculum and its ability to promote mathematical literacy in the classroom. Strengths and suggestions were provided. The feedback is as follows.

#### **Strengths**

- Having students work together allows them to build their relationships with each other and their mathematical understanding of the concepts at the same time.
- The increased focus on vocabulary will help students move their knowledge of quadratics from short term memory to long term memory.
- The lessons build students' confidence around mathematics and allows them to realize they know more than they think they do.
- The lessons show that the teacher has not only a great understanding of mathematics but also a great understanding of what the students need to be and feel successful.

#### **Suggestions**

- In lesson 2, when the KWL is introduced, first go over the non-mathematics KWL as a class in order for students to gain familiarity with the process. Then, for the given math problem, have students work in

groups of two or three to struggle through the KWL process without teacher support. It may be helpful to have a few guiding questions prepared to get more out of students, but refrain from giving too much assistance. Look over the students' KWLs before the next class and use the think aloud at the beginning of lesson three to address and strengths, weaknesses, and misconceptions.

- Lesson 4 can be made into a cross-curricular activity. One way would be to have senior Physics students can put on a demonstration showcasing how gravity affects different objects. Another possibility is to collaborate with the physical education teacher and have students experiment dropping or throwing a football, baseball, kickball, and badminton birdie to see how the shape, size, and mass of an object affects how it falls. This type of activity may add another day in to the unit but the likely increase in student engagement and ability to incorporate tactile learning will help students better learn.

### **Final Thoughts**

Mathematical literacy is a vital component of mathematics instruction today, as it has been for years. Educators are trying to help students prepare for college or career, both of which require good communication skills and the ability to problem solve. Mathematical literacy lends itself to both of these. Embedding mathematical literacy in to the curriculum, as opposed to teaching mathematics and literacy strategies separately, helps students better learn the language of mathematics and ultimately to share ideas fluently with classmates, teachers, professors, or professionals.

The provided unit incorporates the literacy strategies of a Frayer model and KWL chart within lessons on the applications of quadratics functions. For the best results, I believe that strategies such as these should be introduced early in the year and used regularly in every unit. A great action research project would be for a teacher to compare vocabulary understanding as well as overall achievement between two groups of students, one of which is incorporating these literacy strategies and more. So much of mathematical literacy is learned on a daily basis by great teachers who push their students to communicate mathematically, explain their reasoning, and work to become more independent thinkers. By maintaining high expectations of our students as well as ourselves, we can hope for improved test scores, and more importantly career and college readiness.

## Appendices

### Appendix A

Name \_\_\_\_\_ Week of: \_\_\_\_\_

#### Learning Targets:

- ✓ I can factor a quadratic expression in order to reveal its zeros.
- ✓ I can graph linear, exponential, and quadratic functions that are expressed symbolically.

#### Day 1

1. Solve  $m^2 - 5m = -6$  for  $m$  by factoring.

$$\begin{aligned} m^2 - 5m + 6 &= 0 \\ (m-2)(m-3) &= 0 \\ m=2 \quad m=3 \end{aligned}$$

2. Solve the equation for  $x$   
 $(7x-1)(2x+5) = 0$

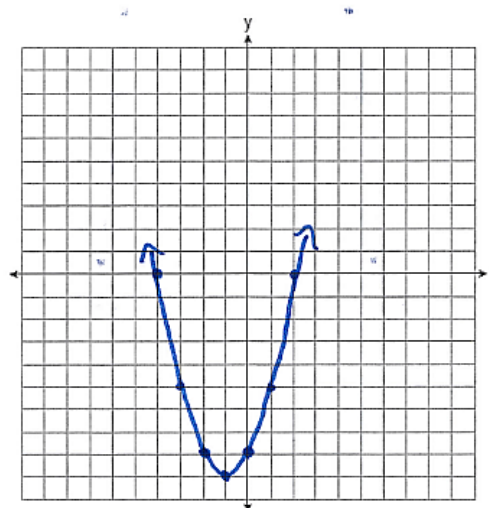
$$\begin{array}{ll} 7x-1=0 & 2x+5=0 \\ +1 \quad +1 & -5 \quad -5 \\ 7x=1 & 2x=-5 \\ x=\frac{1}{7} & x=-\frac{5}{2} \end{array}$$

#### Day 2

1. The zeros of the function  $f(x) = 3x^2 - 3x - 6$  are

$$\begin{aligned} 3x^2 - 3x - 6 &= 0 \\ 3(x^2 - x - 2) &= 0 \\ 3(x-2)(x+1) &= 0 \\ x=2 \quad x=-1 \end{aligned}$$

2. On the set of axes below, graph the equation  $y = x^2 + 2x - 8$ . Using the graph, determine and state the roots of the equation  $x^2 + 2x - 8 = 0$ .



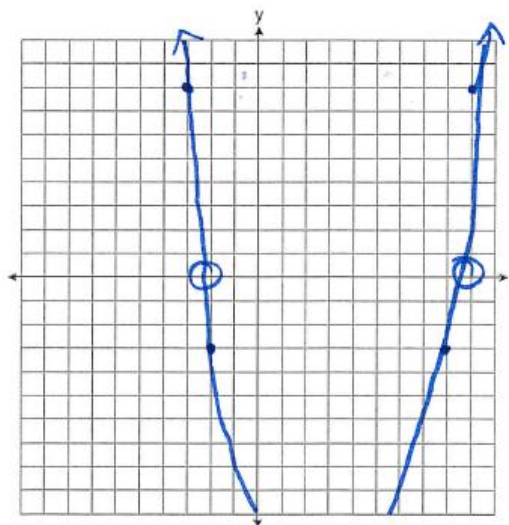
$$x = -4 \quad x = 2$$

**Day 3**

1. What is the difference between zeros and roots?

They are the same thing, the value of  $x$  when  $y=0$  for a quadratic function.

2. On the set of axes below, graph  $y = x^2 - 6x - 19$ . Circle the roots.

**Day 4**

1. Keith determines the zeros of the function  $f(x)$  to be  $-6$  and  $5$ . What could be Keith's function? *Hint: Work backwards.*

$$\begin{aligned} x &= -6 & x &= 5 \\ x+6 &= 0 & x-5 &= 0 \\ (x+6)(x-5) &= 0 \\ x^2+x-30 &= 0 \end{aligned}$$

2. What is the axis of symmetry and vertex of yesterday's warm up graph?

axis of sym:

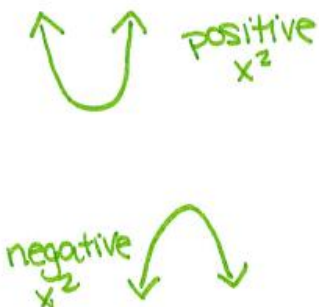
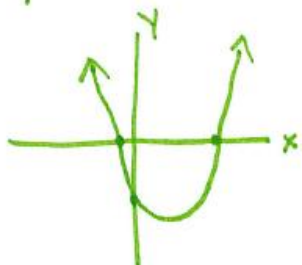
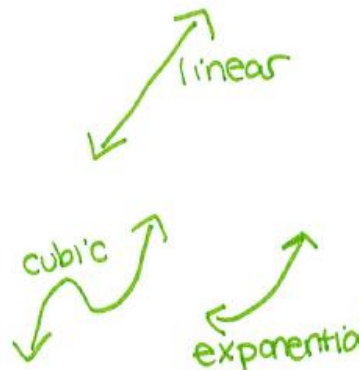
$$x = 3$$

vertex:

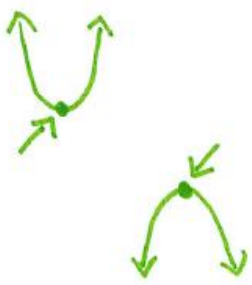
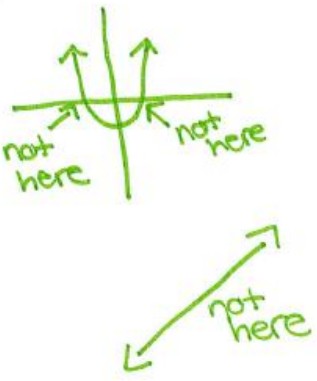

$$(3, -28)$$

## Appendix B

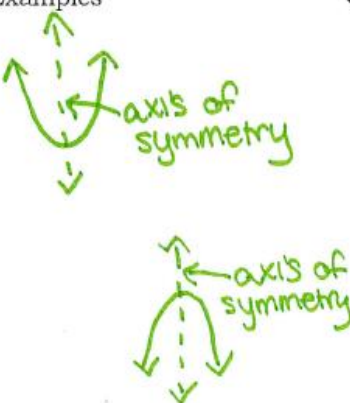

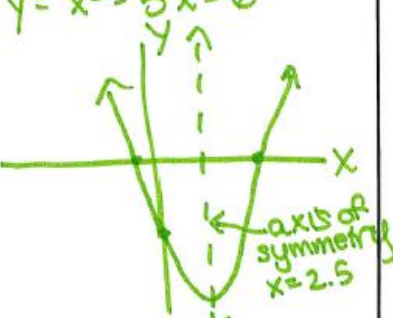
Students should already have some familiarity with these vocabulary words and concepts. The intention of completing these Frayer models are so that the teacher can assess if the student has yet mastered the vocabulary or if there are any misconceptions that need to be cleared up. One Frayer model may be done as an example, either with one of the vocabulary words or a general knowledge topic, and after the one example students should be responsible for correctly filling out their own Frayer models for the remaining words.

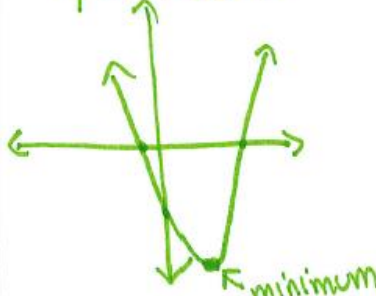



<b>Definition</b> the u-shaped graph created by a quadratic function	<b>Facts/Characteristics</b> - has a minimum or maximum (aka vertex) - y-values show a symmetrical property
<b>Examples</b> 	<b>Visual Representation</b> $y = x^2 - 5x - 6$ 
<b>Non-examples</b> 	



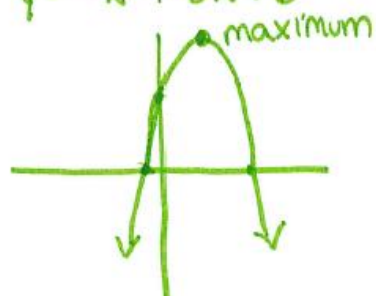



<p>Definition</p> <p>the turning point of a parabola</p>	<p>Facts/Characteristics</p> <p>- is either the highest point or lowest point on the graph</p>
<p>Vertex</p>	
<p>Examples</p> 	<p>Non-examples</p> 
<p>Visual Representation</p> <p><math>y = x^2 - 5x - 6</math></p> 	

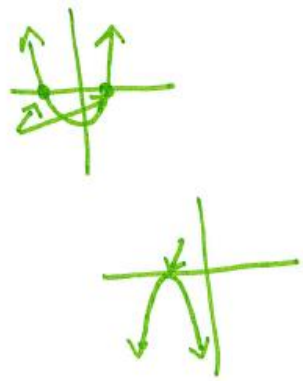
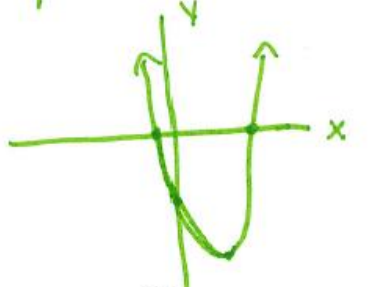
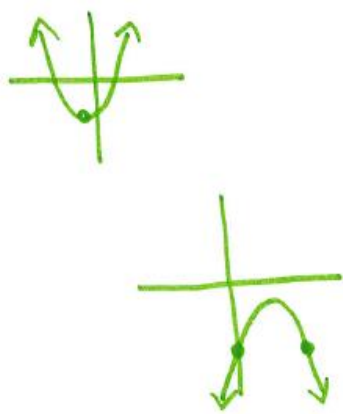
16

<p>Definition</p> <p>the line that cuts a parabola in to two equal sides</p>	<p>Facts/Characteristics</p> <ul style="list-style-type: none"> <li>- vertical line</li> <li>- goes through the vertex</li> <li>- written as <math>x = \text{a number}</math></li> </ul>
<p>Axis of Symmetry</p>	
<p>Examples</p> 	<p>Non-examples</p> 
<p>Visual Representation</p> <p><math>y = x^2 - 5x - 6</math></p> 	

Definition	<p>the lowest point of a parabola</p>		Facts/Characteristics
	<p>minimum</p>		<p>- occurs when <math>x^2</math> has a positive coefficient - in reference to vertex</p>
Examples	<p>Visual Representation</p> <p><math>y = x^2 - 5x - 6</math></p> 		Non-examples
			 

16

Definition	<p>the highest point of a parabola</p>		Facts/Characteristics
	<p>maximum</p>		<p>- occurs when <math>x^2</math> has a negative coefficient - in reference to vertex</p>
Examples	<p>Visual Representation</p> <p><math>y = -x^2 + 5x + 6</math></p> 		Non-examples
			 

Definition	Facts/Characteristics
the point(s) where the parabola intersects the x-axis	- occurs when $y = 0$ - can be found by factoring, using the quadratic formula or the calculator
Examples	Non-examples
	<div data-bbox="609 483 1015 915"> <p>Visual Representation</p> <p><math>y = x^2 - 5x - 6</math></p>  </div> <div data-bbox="1015 483 1403 915">  </div>

**Appendix C**

Throughout this lesson please make sure that students are reading and speaking mathematically as much as possible. Call on students to read the word problem, have students explain what they know for the K column of the KWL, and ask clarifying questions to help students verbalize what they want to know for the W column. This lesson is an introduction to the KWL protocol, so be sure to take the time for students to understand the process.

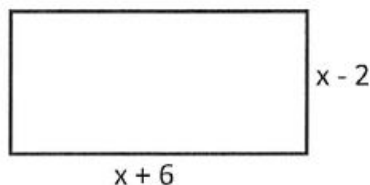
Depending upon the class dynamic, working in partners or a think-pair-share protocol may help promote mathematical conversation for all. Finally, be sure to have students justify why an answer is or is not reasonable (ie a positive vs a negative solution) and if needed, remind students that labeling their answer with units also promotes a higher level of mathematical literacy.

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## KWL's and Geometric Applications

Directions: Read the following word problem and fill out your KWL to help you find a solution.

Find the length and the width of the following rectangle if the area is 105 square inches.



$$A = lw$$

$$105 = (x+6)(x-2)$$

$$105 = x^2 + 4x - 12$$

$$0 = x^2 + 4x - 117$$

$$x = 9$$

$$x = -13$$

reject negative  
answer since we  
cannot have a  
negative distance

length

$$x + 6$$

$$9 + 6$$

15 inches

width

$$x - 2$$

$$9 - 2$$

7 inches



Topic/Problem # HWL + Geometric Applications

<p><b>I</b> <b><u>Know</u></b></p>	<p><b>I</b> <b><u>Want to know</u></b></p>	<p><b>I</b> <b><u>Learned</u></b></p>
<p>length = <math>x+6</math> width = <math>x-2</math> area = 105 square inches area formula <math>A = lw</math></p>	<p>- the length - the width</p>	<p>The length is 15 inches and the width is 7 inches.</p> <p>we cannot choose the negative value of <math>x</math> for this type of problem because it doesn't make sense to have a negative distance.</p>

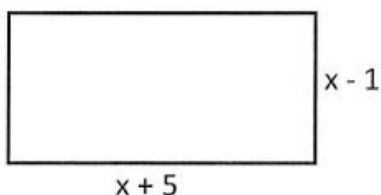
Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## Exit Ticket

Below is a sample of work from a problem similar to the one you did in class today. This student did not earn full credit for their work and isn't sure why, please help the student find their error.

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
$\text{length} = x + 5$ $\text{width} = x - 1$ $\text{area} = 160 \text{ square inches}$ $A = lw$	$-\text{length}$ $-\text{width}$	$x = 11$

Find the length and the width of the following rectangle if the area is 160 square inches.



$$\begin{aligned}
 lw &= A \\
 (x+5)(x-1) &= 160 \\
 x^2 + 4x - 5 &= 160 \\
 x^2 + 4x - 165 &= 0 \\
 x &= 11 \quad x = -15 \\
 &\quad \text{reject}
 \end{aligned}$$

The student did not earn full credit because (answers may vary) the student only found the value of  $x$ . She was supposed to find the length and the width.

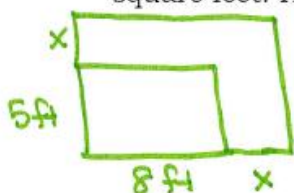
**Appendix D**

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

**Geometric Applications of Quadratic Functions**

Directions: Read each of the following word problems and fill out your KWL to help you find a solution.

1. Faith is having a rectangular dance floor at her Sweet 16 birthday party. The dance floor currently measures 8 feet by 5 feet. She wants to increase the length and width by the same amount so that the total area of the dance floor is 108 square feet. How many feet will Faith need to add to each side?



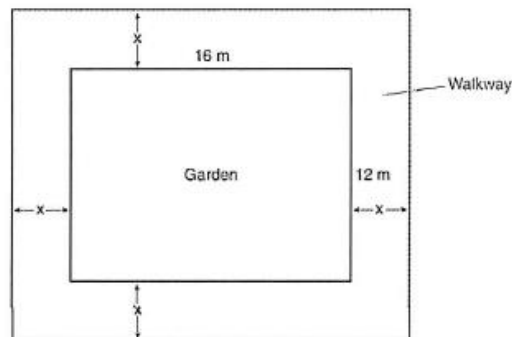
$$\begin{aligned}(x+5)(x+8) &= 108 \\ x^2 + 13x + 40 &= 108 \\ x^2 + 13x - 68 &= 0 \\ x &= 4 \quad x = -17 \\ &\quad \text{reject}\end{aligned}$$

\*don't need to find length and width for this problem

2. A rectangular garden measuring 12 meters by 16 meters is to have a walkway installed around it with a width of  $x$  meters, as shown in the diagram below. Together, the walkway and the garden have an area of 396 square meters.

Write an equation that can be used to find  $x$ , the width of the walkway.

$$(12+2x)(16+2x) = 396$$



Determine and state the width of the walkway.

$$\begin{aligned}4x^2 + 56x + 192 &= 396 \\ 4x^2 + 56x - 204 &= 0 \\ x &= 3 \quad x = -17 \\ &\quad \text{reject}\end{aligned}$$



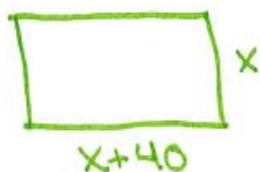
Topic/Problem #: Geometric App. #1

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<ul style="list-style-type: none"> <li>-current dance floor is 8 ft by 5 ft</li> <li>-area of new floor needs to be 108 square feet</li> <li>-both sides increase by the same amount</li> <li>-current area is 40 feet</li> </ul>	<ul style="list-style-type: none"> <li>-How many feet are being added to each side?</li> <li>-What will this dance floor look like with the increase?</li> </ul>	<p>4 feet will be added to each side of the dance floor.</p>

Topic/Problem #: Geometric App. #2

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<ul style="list-style-type: none"> <li>-original garden is 12 meters by 16 meters</li> <li>-walkway is being added around it</li> <li>-total area of garden + walkway is 396 square meters</li> <li>-<math>A = lw</math></li> </ul>	<ul style="list-style-type: none"> <li>-the width of the walkway</li> <li>-what are meters?</li> </ul>	<p>The width of the walkway is 3 meters.</p>

3. A school is building a rectangular lacrosse field that has an area of 6000 square yards. The field must be 40 yards longer than its width. Find the dimensions of the field, in yards.



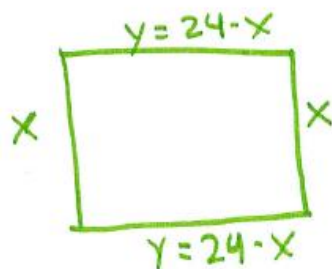
$$\begin{aligned}
 A &= lw \\
 6000 &= x(x+40) \\
 6000 &= x^2 + 40x \\
 0 &= x^2 + 40x + 6000 \\
 x &= 60 \quad x = -100 \text{ reject}
 \end{aligned}$$

length  
60 + 40

100 yards

width  
60 yards

4. Alexis has 48 meters of fencing to use around the perimeter of her rectangular garden. The length of one side of the garden is represented by  $x$ , and the total area of the garden is 108 square meters. What are the dimensions of the garden?



$$\begin{aligned}
 2x + 2y &= 48 \\
 2y &= 48 - 2x \\
 y &= 24 - x
 \end{aligned}$$

$$\begin{aligned}
 lw &= A \\
 x(24 - x) &= 108 \\
 24x - x^2 &= 108 \\
 -x^2 + 24x - 108 &= 0 \\
 x &= 6 \quad x = 18
 \end{aligned}$$

length = ~~6~~  
width = 18

Topic/Problem #: Geometric App. #3

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<ul style="list-style-type: none"> <li>-rectangular field</li> <li>-length is 40 more than width</li> <li>-total area is 6000 square yards</li> <li>-let <math>x = \text{width}</math> <math>x + 40 = \text{length}</math></li> </ul>	<ul style="list-style-type: none"> <li>-the dimensions</li> <li>-what does dimension mean? ↳ length + width</li> </ul>	<ul style="list-style-type: none"> <li>-length is 100 yards</li> <li>-width is 60 yards</li> </ul>

Topic/Problem #: Geometric App. #4

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<ul style="list-style-type: none"> <li>-48 meters of fencing</li> <li>- <math>x = \text{length}</math></li> <li>- <math>P = 2l + 2w</math></li> <li>-area is 108 square meters</li> </ul>	<ul style="list-style-type: none"> <li>-how do I represent the width? (<math>24 - x</math>)</li> <li>-do I need to draw a picture? (yes)</li> <li>-find length + width</li> </ul>	<ul style="list-style-type: none"> <li>-length is 6 meters</li> <li>-width is 18 meters</li> </ul>



**Appendix E****Projectile Motion**

Directions: Read each of the following word problems and fill out your KWL to help you find a solution.

1. Quadir tossed a penny into the air while standing on a 20 foot high bridge. The path of the penny's height can be modeled by the equation  $h(t) = -16t^2 + 40t + 20$ . Find the maximum height of the penny. Justify your answer.

maximum height is  
45 feet.

I found this by putting the equation in  $y=$  in the calculator. Then I hit and trace maximum to find the highest point.

2. Chynia and Dihyona threw their math books out of a window that is 20 feet from the ground. Using the equations of the books' paths below, whose book will reach the ground first? By how many seconds?

Chynia:  $h(t) = -16t^2 + 20$

Dihyona:  $-16t^2 + 8t + 20$

$$0 = -16t^2 + 20$$

$$t = 1.12$$

$$t = -1.12$$

reject

$$0 = -16t^2 + 8t + 20$$

$$t = -.90 \quad t = 1.40$$

reject

$$1.40 - 1.12 = 0.28 \text{ seconds faster}$$

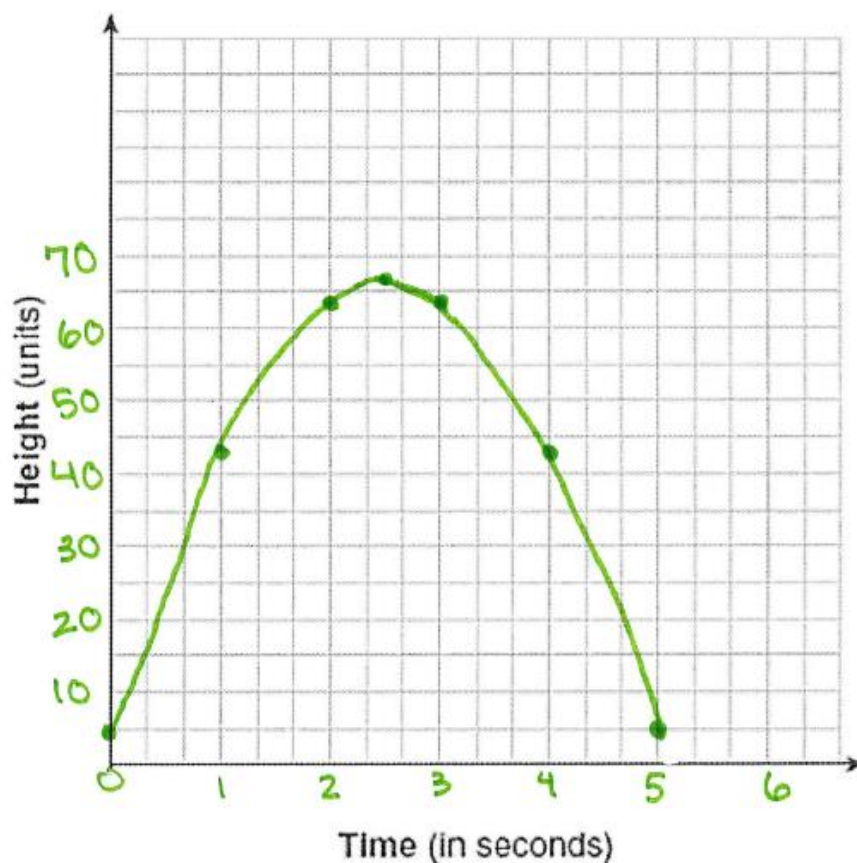
Topic/Problem #: Projectile Motion #1

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<p>- penny starts at 20 feet high</p> $h(t) = -16t^2 + 40t + 20$	<p>- maximum height</p> <p>- How do I justify my answer? (show work or explain)</p>	<p>maximum height is 45 feet</p>

Topic/Problem #: Projectile Motion #2

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
<p>- start at 20 feet high</p> <p>Chynia</p> $h(t) = -16t^2 + 20$ <p>Dihyana</p> $h(t) = -16t^2 + 8t + 20$	<p>- whose book will reach the ground first?</p> <p>- how much faster will it be than the other one?</p>	<p>- still reject negative answers, can't have a negative time</p> <p>- Chynia's will land on the ground first, by 0.28 seconds</p>

3. Alex launched a ball into the air. The height of the ball can be represented by the equation  $h = -9.8t^2 + 49t + 5$ , where  $h$  is the height, in units, and  $t$  is the time, in seconds, after the ball was launched. Graph the equation from  $t = 0$  to  $t = 5$  seconds.



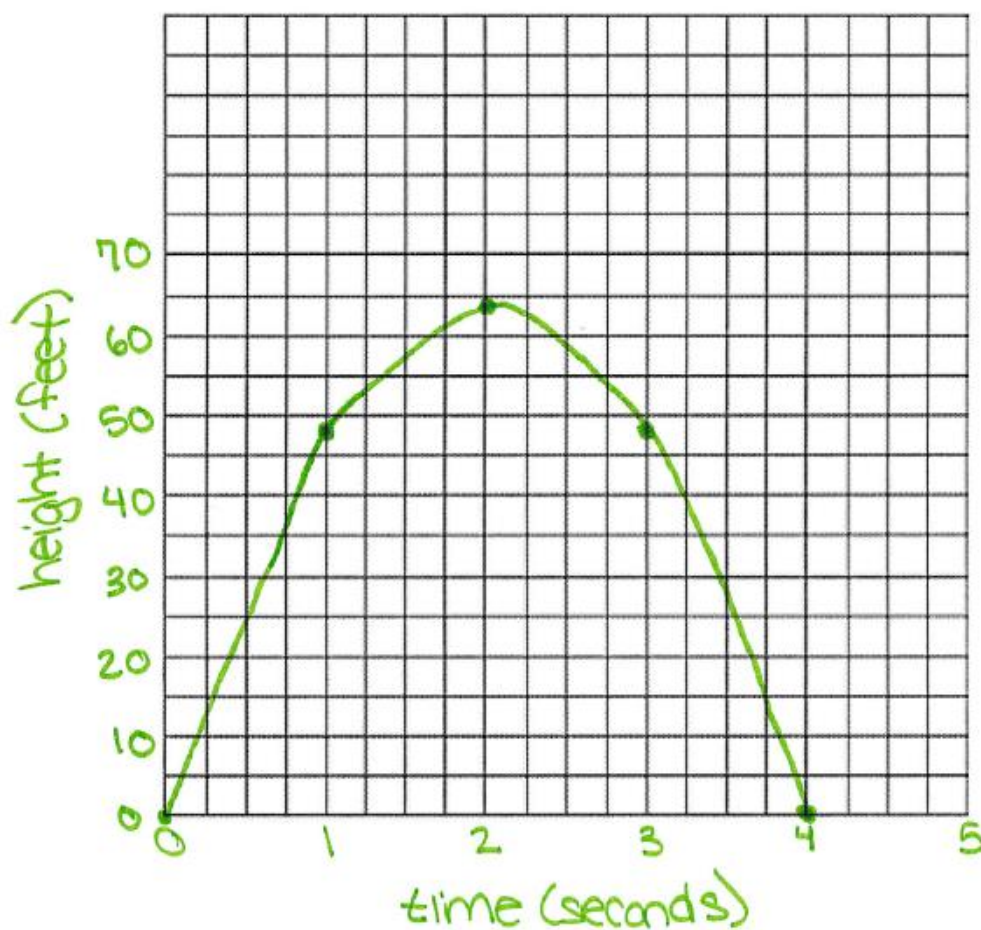
State the coordinates of the vertex and explain its meaning in the context of the problem.

$(2.5, 66.25)$

After 2.5 seconds, the ball is at its highest point at 66.25 units.



4. The path of a rocket fired during the a fireworks display is given by the equation  $s(t) = 64t - 16t^2$ , where  $t$  is the time, in seconds, and  $s$  is the height, in feet. What is the maximum height, in feet, the rocket will reach? How many seconds will it take for the rocket to hit the ground?



maximum height is 64 feet

rocket hits the ground at 4 seconds

Topic/Problem #: Projectile motion #3

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
-ball starts at 5 feet high $h = -9.8t^2 + 49t + 5$	- why do I only graph from $t=0$ to $t=5$ ? - find the vertex - how do I find the meaning in context? ↑ what does that mean?	- context means to explain it in the story or situation - I can change the window on the calc to match my graph - vertex is $(2.5, 66.25)$

Topic/Problem #: Projectile motion #4

I <u>Know</u>	I <u>Want to know</u>	I <u>Learned</u>
-firework starts on the ground (height = 0) $s(t) = 64t - 16t^2$	- what is the maximum height? - how long until the rocket hits the ground? - why is $s$ used for height?	- max height is 64 feet - rocket hits ground at 4 seconds



**Appendix F**

Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

**Applications of Quadratic Functions Assessment**Directions: Answer each question with the correct term.

1. What is a vertex called when it is the lowest point of a parabola?

minimum

2. What is a vertex called when it is the highest point of a parabola?

maximum

3. What are three different names for the point(s) where a parabola intersects the x-axis?

zeros      rootsx-interceptssolutions

4. What is the U-shaped curve called that is created by a quadratic function?

parabola

5. What is the name of the turning point of a parabola?

vertex

6. What is the vertical line that cuts a parabola into two equal parts?

axis of symmetry

7. A circus acrobat is shot out of a cannon with an initial upward speed of 50 ft/sec. The equation for the acrobat's pathway can be modeled by  $h = -16t^2 + 50t + 4$ .

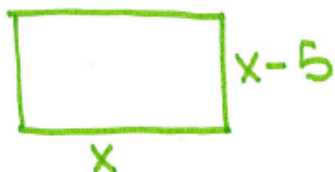
a. Find the maximum height of the acrobat.

43 feet

b. How long will it take to reach the ground?

3.2 seconds

8. The length of a rectangle is five feet less than its width. If the area of the rectangle is 84 square feet, find its dimensions.



$$\begin{aligned}x(x-5) &= 84 \\x^2 - 5x &= 84 \\x^2 - 5x - 84 &= 0\end{aligned}$$

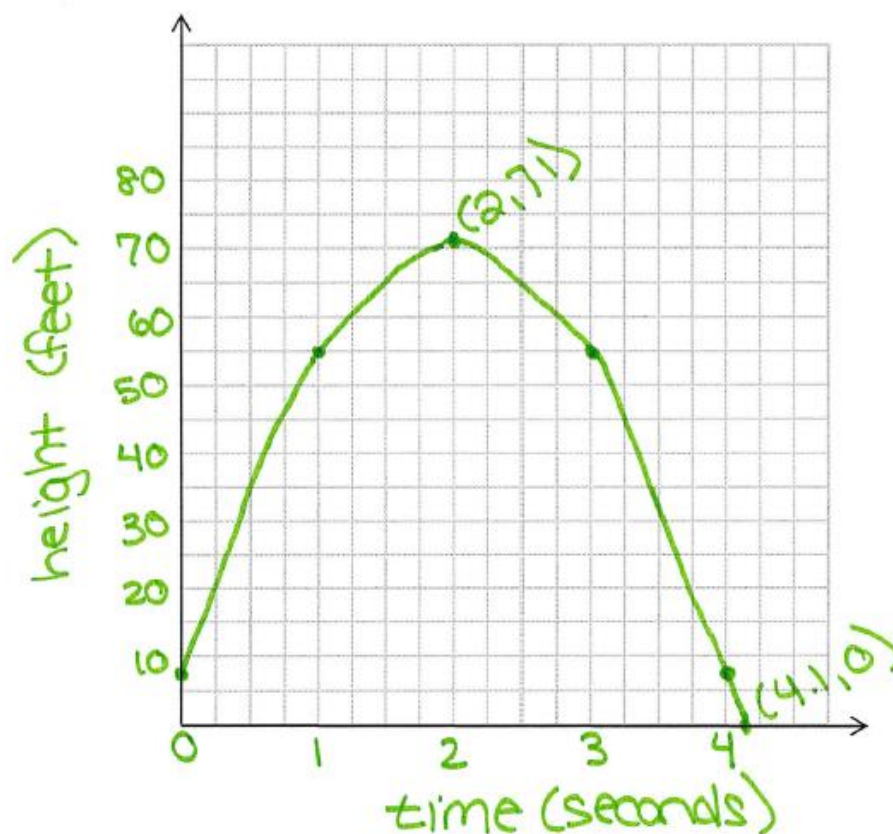
$$x = 12 \quad x - 5 = 7$$

Length 7 feet

Width 12 feet

9. As part of his science fair project, Jordan launched a model rocket from a platform in the middle of a field. The function  $h(t) = -16t^2 + \quad + 7$  represents the height, in feet, of the rocket, and  $t$  represents the time, in seconds, since the rocket was launched.

- a. Graph and label  $h(t)$  on the grid below from the time the rocket is launched ( $t = 0$ ) until it hits the ground.



- b. Determine the maximum height of the rocket *and* the time it takes the rocket to reach that height. **Label the point** on your graph that represents where this occurs.

max height 71 feet  
time 2 seconds

- c. State how long it takes the rocket to hit the ground *to the nearest tenth of a second*. **Label the point** on your graph that represents where this occurs.

4.1 seconds

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